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Diagnosis of Types of Diseases in Cassava Plant by Bayes Method

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Abstract- This research was conducted to implement the Bayes algorithm in an expert system to diagnose types of diseases in cassava plants. The research data was taken from the Binjai City Agriculture and Fisheries Office in 2018. The expert system was built based on the web, where the application was built using the PHP programming language and MySQL DBMS. The results showed that the Bayes algorithm can be used in expert system applications to diagnose types of cassava plant diseases. In the Bayes algorithm, the knowledge base is taken from the data of the amount of data from cassava plants that suffer from disease, so the results of diagnosing cassava plants are based on existing data. Therefore, the more patient data that is used as a knowledge base, the better the diagnosis results are given.

***Keywords*: Expert System, Bayes Method, Cassava**

I. INTRODUCTION

Tubers are plants that have been used by humans for thousands of years as a daily staple food. So that the tubers are cultivated on a large scale given the human need for tubers is still very high. The planted tubers are composed of many types of tubers, such as cassava, potatoes, sweet potatoes, and so forth. As with other plants, tuber plants are also not immune from disease, especially on cassava.

Cassava is known as a plant that is very easy to cultivate. Cassava does not really need land with special conditions, and without special care. So this has become one of the reasons this plant is widely cultivated. Although cassava plants are very easy to cultivate and easy to grow, that does not mean these plants do not have the disease [1]. Based on observations of the Binjai City Agriculture and Fisheries Office conducted in 2018, there were 6 diseases affecting the cassava plants with the following percentage:

Table 1. Percentage of Disease in Cassava

Types of Cassava Diseases	Percentage (%)
Brown Leaf Spots	19,65
Baur Leaf Spots	14,12
White Leaf Spots	21,91
Leaf Bacteria	12,09
Anthracnose	9,07
Rot at the Base of the Stem/Root	23,17

From the above data, it can be seen that stem rot/root disease is the most dominant disease affecting cassava plants with a rate of 23.17%. Then followed by White Leaf Patches with a percentage of 21.91%, then Brown Leaf Patches with 19.65%, then Baur Leaf Patches with a percentage of 14.12%, and the least is Anthracnose disease with a percentage of 9.07.

Various diseases if left unchecked will cause death in plants that cause crop failure or decreased production. If this happens, it will be detrimental to farmers specifically, and in general, will cause cassava scarcity in the market which will increase the price of cassava.

Many beginner cassava farmers do not really understand the diseases that occur in their plants, so sometimes they just let the plants get the disease without doing any treatment to prevent the disease from infecting other plants. This occurs due to the lack of information known by farmers about cassava plant diseases.

The development of information technology, especially the rapid development of artificial intelligence provides a lot of convenience for humans to more quickly and more easily solve various problems encountered. An expert system is one of the groups of knowledge in information technology that is able to have knowledge and intelligence like an expert who can diagnose a problem and provide the solutions needed to solve the problem. Where the concept of an expert system is how the knowledge of an expert is transferred into a computer so that the computer is able to think and act like an expert in diagnosing problems. Therefore, it is possible for humans to consult with computers and no longer need experts [2].

Expert systems are very beneficial for humans, where an expert can be duplicated as much as humans want to meet existing needs, so this is very economically beneficial. As explained earlier, there are not many beginner cassava farmers who do not know the diseases that attack cassava plants, thus providing an obstacle for farmers in diagnosing cassava diseases that they are planting, whereas there are only a few farmers that they can make a consultation place to ask questions about the problem. Therefore, the phenomenon is that there are few experts or farmers who really understand the disease in cassava plants while the need for experts or farmers who understand cassava plant diseases is quite high plus the use of the services of an expert tends to be quite expensive so it is not economical [3].

To that end, these problems can be answered by implementing an expert system to help cassava farmers to

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diagnose and overcome various diseases that attack the plants they plant. Where the knowledge of a cassava plant disease expert will be transferred to a computer and then used into an expert system that can be used by thousands of cassava farmers throughout Indonesia in particular [4].

The expert system has several methods that can be applied, one of which is the Bayes method. Where this method will classify answers based on the probability of cases that occur so that the more cases that occur and are embedded into the knowledge base, the answers are given will be more accurate. This is quite in accordance with the ability of farmers who always learn from experience, with the Bayes method, this can be done so that the more experience is invested in the knowledge base, the answers given will be more accurate [5]–[7].

II. METHOD

Bayes theorem, taken from the name Rev. Thomas Bayes. In the 18th century Thomas Bayes, a British Presbyterian priest. Because of his interest in mathematics, Bayes tried to develop a formula to determine the probability that God really existed based on facts contained on earth. Then Laplace refined the findings and gave it the name "Bayes' Theorem" with the formula below: [8], [9]

$$P(H|E) = \frac{P(E|H) x\, P(H)}{P(E)} \qquad (1)$$

Information:
P (H | E): Hypothesis probability H if there is evidence E
P (E | H): Probability of E evidence to occur if H hypothesis is known
P (H) : H hypothesis probability regardless of any evidence
P (E) : Probability of evidence E

The application of the Bayes theorem to overcome uncertainty, if more than one evidence emerges is written as follows: [10]

$$P(H|E,e) = \frac{P(e|E,H)\, x\, P(H)}{P(e|E)} \qquad (2)$$

Information:
e : Old evidence
E : New evidence
P (H | E, e) : The probability of a hypothesis H, if new evidence emerges E from the old evidence e
P (e | E, H) : Probability of the relationship between e and E if the hypothesis H is true
P (e | E) : Probability of relation between e and E regardless of any hypothesis
P (H | E) : Hypothesis probability H if there is evidence E

The formula for the conditional probability P (H_i∩E) for any event E in the Bayes algorithm can be written with the formula below: [11], [12]

$$P(H_i|E_1E_2 \ldots E_m) = \frac{P(E_1|H_i)\, x\, P(E_2|H_i) x \ldots x\, P(E_m|H_i) x\, P(H_i)}{\sum_{k=1}^{n} P(E_1|H_k)\, x\, P(E_2|H_k) x \ldots x\, P(E_m|H_k) x\, P(H_k)} \qquad (3)$$

Information:
P (H_i | E) : The conditional probability of a hypothesis Hi occurs if the evidence is provided
P (E | H_i) : The probability that an E proof occurs will affect the Hi hypothesis
P (H_i) : The initial probability of the Hi hypothesis occurs regardless of any evidence
P (E) : The initial probability of evidence E occurs regardless of the hypothesis / other evidence.

The research methodology used in this study follows the following flow:

A. Problem analysis

Analyze the problems that occur that are the main topics in research to be resolved.

B. Study of literature

Look for a variety of literature both in books, national journals, international journals, and the results of other scientific work around the problem to be solved.

C. Troubleshooting Analysis

Analyze how problem-solving is the topic of research to be proposed as an alternative solution to the problem. To solve the problem that has been explained in the problem analysis, then we need a suitable algorithm that can be applied as problem-solving. the algorithm chosen is the Bayes algorithm. Bayes algorithm can be used to calculate the probability of an event occurring based on the effect obtained from the results of observations. So based on available data, the Bayes algorithm can calculate the probability of cassava-based on the symptoms experienced.

D. Knowledge Base Design

Design a knowledge base that will be used in expert systems as a source of knowledge in making a diagnosis. Based on statistical data of cassava disease taken at Binjai City Agriculture and Fisheries Office in 2018, there are 397 known cassava trees that have positive diseases with the following types of diseases:

Table 2. Number of Sufferers from Each Type of Cassava Disease

Symbol	Types of Cassava Diseases	Number of Sufferers
H1	Brown Leaf Spots	78
H2	Baur Leaf Spots	56
H3	White Leaf Spots	87
H4	Leaf Bacteria	48
H5	Anthracnose	36
H6	Rot at the Base of the Stem/Root	92
	TOTAL	**397**

Symptoms data for each cassava disease can be seen in the following table:

Table 3. Number of Each Symptom of Each Type of Cassava Disease

Symbol	Symptoms	Number of Symptoms of Each Type of Cassava Disease					
		H1	H2	H3	H4	H5	H6
E1	The disease attacks the old leaves	76	55	76	0	0	12
E2	Leaf spot on the bottom	68	2	3	0	2	3
E3	White/brown patches on the top of the leaf	66	7	43	3	1	8
E4	The edges are fringed with purple circles	74	5	2	0	1	2
E5	Brown spots on leaves	54	48	2	7	1	8
E6	Crimped leaves	59	51	76	45	0	2
E7	The leaves fall/fall	64	2	87	3	5	9
E8	Perforated leaf	49	2	8	7	4	0
E9	Yellowing of leaves	77	24	65	34	1	90
E10	Dried leaves	62	34	86	41	8	43
E11	There is fungus at the bottom of the leaf	34	41	12	10	3	1
E12	Large patches	9	44	3	11	2	6
E13	Often spots on the tips of leaves	4	27	13	7	2	0
E14	Inverted V-shaped patches	7	39	0	3	1	0
E15	The top leaves are brown evenly	7	8	0	4	0	0
E16	The lower leaves are gray	3	21	7	9	2	3
E17	The middle of the gray patch producing fungi	1	0	82	9	2	5
E18	Attacking young leaves	0	2	69	0	1	16
E19	Attacking leaves and stems	0	1	16	29	1	11
E20	The initial symptoms are gray lesions	9	6	0	37	1	2
E21	The lesions are limited by the leaf bones and form angles	6	4	2	42	5	0
E22	Lesion extends into necrotic spots	4	8	5	44	7	0
E23	The bacterial mass that occurs in the stem, leaf blades and stems	3	3	11	39	9	0
E24	withered plant tip	7	2	1	45	11	4
E25	Attacking the surface of goods, petioles, and leaves	11	1	7	2	33	0
E26	There are protuberances on the surface of the stem	14	0	3	1	26	0
E27	Petiole easily broke	5	0	2	0	29	11
E28	Withered leaves	3	4	4	0	21	89
E29	Shrinkage on the cork	2	0	0	4	32	0
E30	Stems break easily	8	2	0	7	30	2
E31	Attacking the base of the stem, roots, and tubers	0	6	3	3	3	92
E32	Premature deciduous leaves	11	7	5	1	7	87
E33	Color damage to roots	12	2	8	2	3	91
E34	Root rot	4	2	9	1	0	89
E35	The tubers are dark and stink	6	1	9	1	1	90

These data can be represented in the knowledge base of the expert system that will be built. Where

P (H) : Probability of occurrence of H disease regardless of anything

P (E | H) : Probability of E symptoms to occur in H disease

In the data above, P (H1) can be found by dividing the number of H1 sufferers by the total cassava plants that are positive for cassava disease, which is 78/397 = 0.196474, so that:

P (H1) = 0.196474.

The P (H) value of each disk can be seen in the following table:

Table 4. P (H) Values for Each Disease

Symbol	Types of Cassava Diseases	N. of Sufferers	$P(P_1)$
H1	Brown Leaf Spots	78	0,196474
H2	Baur Leaf Spots	56	0,141058
H3	White Leaf Spots	87	0,219144
H4	Leaf Bacteria	48	0,120907
H5	Anthracnose	36	0,09068
H6	Rot at the Base of the Stem/Root	92	0,231738

Whereas to find P (E | H) can be done by dividing the number of symptoms of E by the number of sufferers of H, For example, to look for P (E1 | H1), then for the number of symptoms of E1 with the number of suffering from H1, it becomes 76/78 = 0.974359 . So that:

P (E1 | H1) = 0.974359.

The complete data of the P (E | H) value for each symptom can be seen in the following table:

Table 5. P (E | H) values for each symptom of each disease

Symbol	Symptoms	Number of Symptoms of Each Type of Cassava Disease					
		$P(E_i\|H_1)$	$P(E_i\|H_2)$	$P(E_i\|H_3)$	$P(E_i\|H_4)$	$P(E_i\|H_5)$	$P(E_i\|H_6)$
E1	The disease attacks the old leaves	0,974359	0,982143	0,873563	0	0	0,130435
E2	Leaf spot on the bottom	0,871795	0,035714	0,034483	0	0,055556	0,032609
E3	White/brown patches on the top of the leaf	0,846154	0,125	0,494253	0,0625	0,027778	0,086957
E4	The edges are fringed with purple circles	0,948718	0,089286	0,022989	0	0,027778	0,021739
E5	Brown spots on leaves	0,692308	0,857143	0,022989	0,145833	0,027778	0,086957
E6	Crimped leaves	0,75641	0,910714	0,873563	0,9375	0	0,021739
E7	The leaves fall/fall	0,820513	0,035714	1	0,0625	0,138889	0,097826
E8	Perforated leaf	0,628205	0,035714	0,091954	0,145833	0,111111	0
E9	Yellowing of leaves	0,987179	0,428571	0,747126	0,708333	0,027778	0,978261
E10	Dried leaves	0,794872	0,607143	0,988506	0,854167	0,222222	0,467391
E11	There is fungus at the bottom of the leaf	0,435897	0,732143	0,137931	0,208333	0,083333	0,01087
E12	Large patches	0,115385	0,785714	0,034483	0,229167	0,055556	0,065217
E13	Often spots on the tips of leaves	0,051282	0,482143	0,149425	0,145833	0,055556	0
E14	Inverted V-shaped patches	0,089744	0,696429	0	0,0625	0,027778	0
E15	The top leaves are brown evenly	0,089744	0,142857	0	0,083333	0	0
E16	The lower leaves are gray	0,038462	0,375	0,08046	0,1875	0,055556	0,032609
E17	The middle of the gray patch producing fungi	0,012821	0	0,942529	0,1875	0,055556	0,054348
E18	Attacking young leaves	0	0,035714	0,793103	0	0,027778	0,173913
E19	Attacking leaves and stems	0	0,017857	0,183908	0,604167	0,027778	0,119565
E20	The initial symptoms are gray lesions	0,115385	0,107143	0	0,770833	0,027778	0,021739
E21	The lesions are limited by the leaf bones and form angles	0,076923	0,071429	0,022989	0,875	0,138889	0
E22	Lesion extends into necrotic spots	0,051282	0,142857	0,057471	0,916667	0,194444	0
E23	The bacterial mass that occurs	0,038462	0,053571	0,126437	0,8125	0,25	0

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Symbol	Symptoms	Number of Symptoms of Each Type of Cassava Disease					
		$P(E_i \mid H_1)$	$P(E_i \mid H_2)$	$P(E_i \mid H_3)$	$P(E_i \mid H_4)$	$P(E_i \mid H_5)$	$P(E_i \mid H_6)$
	in the stem, leaf blades and stems						
E24	Withered plant tip	0,089744	0,035714	0,011494	0,9375	0,305556	0,043478
E25	Attacking the surface of goods, petioles, and leaves	0,141026	0,017857	0,08046	0,041667	0,916667	0
E26	There are protuberances on the surface of the stem	0,179487	0	0,034483	0,020833	0,722222	0
E27	Petiole easily broke	0,064103	0	0,022989	0	0,805556	0,119565
E28	Withered leaves	0,038462	0,071429	0,045977	0	0,583333	0,967391
E29	Shrinkage on the cork	0,025641	0	0	0,083333	0,888889	0
E30	Stems break easily	0,102564	0,035714	0	0,145833	0,833333	0,021739
E31	Attacking the base of the stem, roots, and tubers	0	0,107143	0,034483	0,0625	0,083333	1
E32	Premature deciduous leaves	0,141026	0,125	0,057471	0,020833	0,194444	0,945652
E33	Color damage to roots	0,153846	0,035714	0,091954	0,041667	0,083333	0,98913
E34	Root rot	0,051282	0,035714	0,103448	0,020833	0	0,967391
E35	The tubers are dark and stink	0,076923	0,017857	0,103448	0,020833	0,027778	0,978261

E. Analysis of the Process in Diagnosing

The process of calculating the results using the Bayes algorithm in full is described in the form of a flowchart below. All symptoms entered by the user will be processed to find the conclusion. The processing showed at the flowchart below:

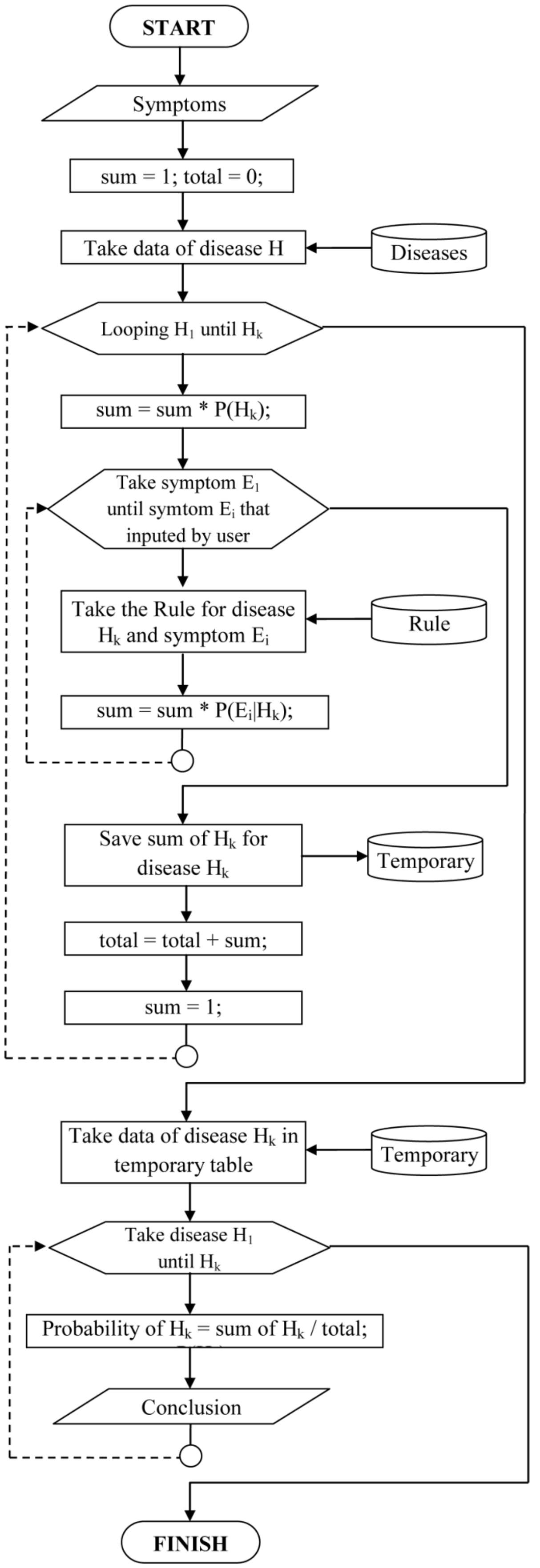

Figure 1. Flowchart Process for Diagnosing Types of Cassava Disease

F. Testing and Analysis

Analyze the results of tests that have been done to give an idea of how effectively the expert system can solve the problem.

G. Conclusion

Make the conclusions from the results of testing and analysis of an expert system test that was successfully built.

III. RESULTS AND DISCUSSION

The results of this study are demonstrated through the testing. Testing is done by selecting the following symptoms:

1. Disease attacks old leaves (E1)
2. Spots fringed with purple circles (E4)
3. There is mold on the underside of the leaf (E11)
4. The lower leaves are gray (E16)
5. Withered plant tip (E24)

To find the probability of an H disease based on the E symptoms that arise, then the following equation is used:

$$P(H_i|E_1E_2\ldots E_3) = \frac{P(E_1|H_i)\ x\ P(E_2|H_i) x \ldots x\ P(E_m|H_i) x\ P(H_i)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_2|H_k) x \ldots x\ P(E_m|H_k) x\ P(H_k)} \quad (1)$$

Based on the above equation, it is possible to find the probability of each H1 disease, up to H6 as follows :

1. H1 (Brown Leaf Spots)

$$P(H_1|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_1)\ x\ P(E_4|H_1)\ x\ P(E_{11}|H_1)\ x\ P(E_{16}|H_1)\ x\ P(E_{24}|H_1)\ x\ P(H_1)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0{,}000273}{0{,}000395}$$

= 0,691585 atau 69,1585%

2. H2 (Baur Leaf Spots)

$$P(H_2|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_2)\ x\ P(E_4|H_2)\ x\ P(E_{11}|H_2)\ x\ P(E_{16}|H_2)\ x\ P(E_{24}|H_2)\ x\ P(H_2)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0{,}000121}{0{,}000395}$$

= 0,306969 atau 30,6969%

3. H3 (White Leaf Spots)

$$P(H_3|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_3)\ x\ P(E_4|H_3)\ x\ P(E_{11}|H_3)\ x\ P(E_{16}|H_3)\ x\ P(E_{24}|H_3)\ x\ P(H_3)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0{,}0000005614}{0{,}000395}$$

= 0,001420778 atau 0,1421%

4. H4 (Leaf Bacteria)

$$P(H_4|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_4)\ x\ P(E_4|H_4)\ x\ P(E_{11}|H_4)\ x\ P(E_{16}|H_4)\ x\ P(E_{24}|H_4)\ x\ P(H_4)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0}{0{,}000395}$$

= 0 atau 0%

5. H5 (Anthracnose)

$$P(H_5|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_5)\ x\ P(E_4|H_5)\ x\ P(E_{11}|H_5)\ x\ P(E_{16}|H_5)\ x\ P(E_{24}|H_5)\ x\ P(H_5)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0}{0{,}000395}$$

= 0 atau 0%

6. H6 (Rot at the Base of the Stem/Root)

$$P(H_6|E_1E_4E_{11}E_{16}E_{24}) = \frac{P(E_1|H_6)\ x\ P(E_4|H_6)\ x\ P(E_{11}|H_6)\ x\ P(E_{16}|H_6)\ x\ P(E_{24}|H_6)\ x\ P(H_6)}{\sum_{k=1}^{n} P(E_1|H_k)\ x\ P(E_4|H_k)\ x\ P(E_{11}|H_k)\ x\ P(E_{16}|H_k)\ x\ P(E_{24}|H_k)\ x\ P(H_k)}$$

$$= \frac{0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738}{\begin{matrix}0{,}974359 * 0{,}948718 * 0{,}435897 * 0{,}038462 * 0{,}089744 * 0{,}196474 + \\ 0{,}982143 * 0{,}089286 * 0{,}732143 * 0{,}375000 * 0{,}035714 * 0{,}141058 + \\ 0{,}873563 * 0{,}022989 * 0{,}137931 * 0{,}080460 * 0{,}011494 * 0{,}219144 + \\ 0 * 0 * 0{,}208333 * 0{,}1875 * 0{,}9375 * 0{,}120907 + \\ 0 * 0{,}027778 * 0{,}083333 * 0{,}055556 * 0{,}305556 * 0{,}09068 + \\ 0{,}130435 * 0{,}021739 * 0{,}01087 * 0{,}032609 * 0{,}043478 * 0{,}231738\end{matrix}}$$

$$= \frac{0{,}0000000101}{0{,}000395}$$

= 0,0000256284 atau 0,0026%

Based on the calculation above, it can be seen that, the user who inputted symptoms:

1. Disease attacks old leaves (E1)
2. Spots fringed with purple circles (E4)
3. There is mold on the underside of the leaf (E11)
4. The lower leaves are gray (E16)
5. Withered plant tip (E24)

The result showed 69.1585% of the cassava trees were currently getting Brown Leaf Spots (H1) disease. Other possibilities that can occur based on the results of calculations are:

Table 6. List of Possibilities for Other Diseases

No	Disease	Probability (%)
1	Baur Leaf Spots	30,6969
2	White Leaf Spots	0,1421
3	Rot at the Base of the Stem/Root	0,0026
4	Leaf Bacteria	0
5	Anthracnose	0

The results with the application can be seen in the following image:

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Figure 2. Results of the Process to Diagnose with the Application

IV. CONCLUSION

Based on the results of the analysis and testing conducted, the conclusions can be drawn in this study as follows:

1. The expert system with Bayes method can be an inexpensive and easy solution for farmers to diagnose diseases in cassava plants.
2. Bayes method is able to calculate the percentage of the likelihood of a disease based on the symptoms entered by the user, where the higher the percentage of the disease, the higher the likelihood of the disease occurring.
3. Bayes method is suitable to be implemented in expert system applications to diagnose cassava plant diseases.
4. If the user gives random symptoms, the application will still provide diagnosis results. In the Bayes method, the more patient data that is successfully collected as a knowledge base, the more precise or accurate the results obtained.

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